Python-based scientific analysis and visualization of precipitation systems at NASA Marshall Space Flight Center

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At NASA Marshall Space Flight Center (MSFC), Python is used several different ways to analyze and visualize precipitating weather systems. A number of different Python-based software packages have been developed, which are available to the larger scientific community. The approach in all these packages is to utilize pre-existing Python modules as well as to be object-oriented and scalable.

The first package that will be described and demonstrated is the Python Advanced Microwave Precipitation Radiometer (AMPR) Data Toolkit, or PyAMPR for short. PyAMPR reads geolocated brightness temperature data from any flight of the AMPR airborne instrument over its 25-year history into a common data structure suitable for user-defined analyses. It features rapid, simplified (i.e., one line of code) production of quick-look imagery, including Google Earth overlays, swath plots of individual channels, and strip charts showing multiple channels at once. These plotting routines are also capable of significant customization for detailed, publication-ready figures. Deconvolution of the polarization-varying channels to static horizontally and vertically polarized scenes is also available. Examples will be given of PyAMPR's contribution toward real-time AMPR data display during the Integrated Precipitation and Hydrology Experiment (IPHEx), which took place in the Carolinas during May-June 2014.

The second software package is the Marshall Multi-Radar/Multi-Sensor (MRMS) Mosaic Python Toolkit, or MMM-Py for short. MMM-Py was designed to read, analyze, and display three-dimensional national mosaicked reflectivity data produced by the NOAA National Severe Storms Laboratory (NSSL). MMM-Py can read MRMS mosaics from either their unique binary format or their converted NetCDF format. It can also read and properly interpret the current mosaic design (4 regional tiles) as well as mosaics produced prior to late July 2013 (8 tiles). MMM-Py can easily stitch multiple tiles together to provide a larger regional or national picture of precipitating weather systems. Composites, horizontal and vertical cross-sections, and combinations thereof are easily displayed using as little as one line of code. MMM-Py can also write to the native MRMS binary format, and sub-sectioning of tiles (or multiple stitched tiles) is anticipated to be in place by the time of this meeting. Thus, MMM-Py also can be used to power the creation of custom mosaics for targeted regional studies. Overlays of other data (e.g., lightning observations) are easily accomplished. Demonstrations of MMM-Py, including the creation of animations, will be shown.

Finally, Marshall has done significant work to interface Python-based analysis routines with the U.S. Department of Energy's Py-ART software package for radar data ingest, processing, and analysis. One example of this is the Python

Turbulence Detection Algorithm (PyTDA), an MSFC-based implementation of the National Center for Atmospheric Research (NCAR) Turbulence Detection Algorithm (NTDA) for the purposes of convective-scale analysis, situational awareness, and forensic meteorology. PyTDA exploits Py-ART's radar data ingest routines and data model to rapidly produce aviation-relevant turbulence estimates from Doppler radar data. Work toward processing speed optimization and better integration within the Py-ART framework will be highlighted. Python-based analysis within the Py-ART framework is also being done for new research related to intercomparison of ground-based radar data with satellite estimates of ocean winds, as well as research on the electrification of pyrocumulus clouds. Examples of these will be shown.